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Ministry of Economic Affairs

PATENT OF INVENTION

The Minister for Economic Affairs
having regard to the law of 24 May 1854 on Patents of invention;
having regard to the Union Convention for the protection of industrial property;
having regard to the report delivered on the 27 December 1965 at 15 h 20 to the industrial property department;

DECREES:

Article 1. - The company known as : INTERNATIONAL BUSINESS MACHINES CORPORATION,
Armonk, 10.504, New York (United States of America),
represented by Messrs J. Gevers & Company at Brussels,
is granted

a patent of invention for: A speech analysis device intended for a speech identification system,

which it declares to have been the subject of a patent application filed in the United States of America on 22 January 1965 in the name of Mr. G. L. Clapper and of which it is the rightful owner.

Article 2. - This patent is delivered to it without prior examination, at its own risks and peril, without any guarantee of its reality, of its novelty or of the merit of the invention, nor of the exactness of the description, and without prejudice to the rights of third parties.

The present decree will be accompanied by one of the copies of the specification of the invention (descriptive memorandum and possibly drawings) signed by the interested party and filed in support of his patent application.

Brussels, 14 January 1966
by special delegation:
The Director General
(signature illegible)
J. HAMELS.

OCTR. FAM.

D. 6604

CGB/rh

DESCRIPTIVE MEMORANDUM

Filed in support of an application for a

PATENT OF INVENTION

by the Company known as

INTERNATIONAL BUSINESS MACHINES CORPORATION

for

A SPEECH ANALYSIS DEVICE INTENDED FOR

A SPEECH IDENTIFICATION SYSTEM

Under the provisions of the International Convention of 1883, with regard to the patent application filed in the United States of America on 22 January 1965, under No. 427.371, in the name of:

- GENUNG L. CLAPPER

The present invention relates to speech analysis and identification systems and, more particularly, to a system capable of detecting the transitions of formants and to identify the consonants.

The ever greater demands in the field of voice identification systems result from the need to accelerate data communications in all industrial fields and, in particular, in real-time operations for which vocal communication comes into play.

The voice-sensitive systems of the prior art have met with only little success in fields where voice identification and response were limited to specific

sounds, in particular those used for identification of numerical characters, of certain alphabetical words, and within limits largely restricted to a few specific words. These systems have been improved with a view to allowing a corresponding increase in the number of words used, but these improvements have been possible only thanks to the use of larger and bulkier equipment for the speech identification systems, and for storage. Despite these improvements, the systems were limited to voices exhibiting very similar characteristics, and the act of deviating slightly from these characteristics gave rise to a corresponding reduction in the effectiveness of the system. In order to improve the effectiveness of these systems, an adjustable apparatus was attached to them, serving to compensate for the losses resulting from a variation in the uttering of the same spoken words. Further improvements also implemented in the devices of the prior art have made it possible to obtain greater resolution and afforded the possibility of taking account of variants in the voice characteristics of different individuals, in such a way that the apparatus has become capable of analyzing and identifying a greater number of different words. The increase in the capabilities of these systems was accompanied by an increase in the number of storage elements, which often made them bulky and costly.

The present invention avoids the drawbacks of the systems of the prior art by use of a system capable of

detecting the transitions of formants on the basis of frequency and time coordinates. Furthermore, the present invention comprises an apparatus for detection of fricative and voiced sounds capable of detecting, in these formants, the presence of consonants and hence of furnishing vocal characteristics which are much more meaningful and which can be easily joined together into a code system which is much more compact than those used in the systems of the prior art.

As has already been seen in the French Patent No. 1405489 filed by the applicant in France on 17 June 1964, under the title "Speech Analysis System" a formant is a series of energy points closely linked to the local maxima. In the speech frequency band of the sound spectrum, for a given instant in time, there ordinarily exist from one to four of these energy concentrations, or formants, resulting from the passage of air through the mouth and the nose of the human sound generator system. When the words are formed, these energy concentrations spread out, blend or disappear completely.

Consequently, the subject of the present invention is essentially an improved speech identification system furnishing, in a more abbreviated form, a larger number of speech-significant characteristics, which reduces the volume of the storage systems then necessary with respect to those used in the speech identification systems of the prior art.

Another object of the present invention consists

in developing those characteristics of the voice which are necessary for identification of words expressed rather than of the person who has uttered them.

Another object consists in detecting certain characteristics of vocal sounds which permit identification of the consonants, which gives rise to more precise identification of the spoken word.

Another object resides in the production of novel devices and of a novel method for combining the characteristics of the formants with fricative and voiced energies in order to obtain, in the speech spectrum, the vocal characteristics representing the consonants.

Other characteristic objects and advantages of the present invention will emerge from the account which follows, given by reference to the drawing attached to this text which represents preferred embodiments of the invention.

In the drawing:

Figure 1 is the diagram of the system showing the main sections of the invention.

Figure 2 shows how Figures 2a to 2f, which represent the system in accordance with the invention in detail, should be arranged.

Figure 3 represents the preamplifier in detail.

Figure 4 represents ~~the~~ automatic gain control device in detail.

Figure 5 represents the slope detector in detail.

Figure 6 shows certain active elements of one of

the 14 frequency selectors.

Figure 7 represents a detail of the rectifier.

Figure 8 represents a detail of the equilibrium or equality detector.

Figure 9 represents a NAND circuit in detail.

Figure 10 represents a detail of the fricative sound selector.

Figure 11 shows a detail of an integrator invertor connected to the fricative sound selector.

Figure 12 shows a detail of the voice selector.

Figure 13 shows a detail of an integrator invertor connected to the voice selector.

Figure 14 shows the speech control latch in detail.

Figure 15 shows a detail of a pulse shaping and integration device.

Figure 16a shows a detail of the differentiator circuit.

Figure 16b is a time diagram showing the action of the differentiators.

Figure 17 shows a detail of a clamping circuit.

Figure 18 shows a detail of a circuit connected to the outputs of the memory clamping circuits.

Figure 19 shows a detail of an OR circuit

Figure 20 shows an AND circuit in detail

Figure 21 represents a double invertor in detail.

Figure 22 represents a NOR circuit in detail, connected to the output of the double invertors.

In the patent mentioned above, the formants are detected and stored in a matrix in which the reference coordinates are based on frequency and time. This system allowed good speech identification, but the memory requirements for it are significant. Moreover, the detection of consonants therein is relatively difficult, and inexact in certain cases.

In the present invention, novel means are used in order to detect the transitions of formants and in order to achieve simpler recording of them. Furthermore, the detection devices for fricative and voiced sounds use the local maxima of the formants in order to detect the presence of consonants, which makes it possible to obtain voice-characteristic codes whose more precise significance facilitates identification. It transpired that the codes produced by this system do not vary as much from one person to another as the codes produced by the formant referencing systems of the prior art.

The invention will now be described in its entirety. Referring to Figure 1, the vocal sounds or sounds forming part of the speech spectrum gain access to the system by means of a microphone 1 which transforms the vocal sounds into electrical energy, which is amplified in turn by the preamplifier 2. An input sensitivity control device 3 is provided which serves to eliminate parasitic sounds. The preamplifier 2 communicates with an automatic gain control device 35 which provides dynamic adjustment of the gain so as to keep the

output of the preamplifier constant. This output exhibits the form of a compressed condensed speech envelope, which is applied to an output line 30 connected to a frequency analysis system FS, which comprises a certain number of frequency selectors each of which is tuned to a particular frequency band lying between 3750 cycles per second and 260 cycles per second. The speech spectrum established according to a logarithmic scale is divided symmetrically on either side of 1000 cycles. A fricative sound selector is also provided, which is constituted in essence by a high-pass wide-band filter which covers frequencies lying between 4000 and 10000 cycles per second. The system also comprises a voice selector, essentially constituted by a low-pass wide-band filter which covers the frequencies lying between 100 and 250 cycles per second. The frequencies of the spectrum lying between 250 and 3750 cycles per second are divided into 14 bands to which the frequency selectors are tuned. By virtue of these frequency selectors and of a device which is associated with them and which will be described in detail later, the local maxima (formants) corresponding to the point energies present in the vocal spectrum are detected by a formant referencing system FL (which comprises rectifiers, equality detectors, AND circuits and pulse shaping and integration devices). The presence of these formants is signaled to a formant transition detection and storage system in which the passing by, the formants from one band of frequencies to the other is

detected by a method of comparison by differentiation in time and by coincidence in time. This transition detection system also comprises suitable memory clamping circuits intended for storing transient formants. The formants which appear in the form of constant energy levels are detected in a device for detection and storage of invariable formants ISD. In a general way, while the formants are being developed, the possible transitions are as follows:

A local maximum Mi may come to an end and the immediately lower frequency band may initiate a transition Mj; the transition Mi to Mj will be called "decreasing transition" and will bear the designation LiF. This transition is stored in a clamping circuit bearing the designation S.

A local maximum Mi may come to an end and the immediately higher frequency band may initiate a transition Mh. The transition from Mi to Mh will be called "increasing transition" and it will bear the reference MiR. This transition is stored in a clamping circuit bearing the corresponding designation R.

A local maximum Mi may come to an end without either the immediately higher band, nor the immediately lower band undergoing a transition when the local maximum is reached, in which case the latter enters into the category of constant levels and bears the designation MiS. This local maximum is stored in a clamping circuit bearing the corresponding designation S.

The detection of the end of the formants is carried out by a certain number of differentiators DF′ (14 in number) at a rate of one for each of the frequency bands which constitute the vocal spectrum. A second group of differentiators, which bear the references D_2F' (14 in number), in association with other devices which will be described later, serve for detecting the presence of constant (invariable) formants.

The outputs of these differentiators are sent to the corresponding clamping circuits which furnish indications of decreasing and increasing transient conditions, and of constant conditions, indicating vectors, 40 in number, which represent the vowels in the speech spectrum.

The present invention also comprises means making it possible to detect energies which are indicative of vocal characteristics representing consonants in the speech spectrum. Referring to Figure 1, the energies representing the fricative and voiced sounds are sent to the corresponding frequency analyzers whose outputs are directed via a first integration device and from there to a second integration device. The fricative output signal FO, and the voiced output signal VO are sent to a fricative and voiced sound control device FVD, in which a double inversion device and associated coincidence logic circuits make it possible to send out signals representing the following fricative and voiced energy states:

1 - $F.\bar{V}$: fricative energy, without voiced energy

2 - $\bar{F}.V$: voiced energy, without fricative energy

3 - F.V.: simultaneous presence of fricative and voiced energies

4 - $\bar{F}.\bar{V}$: simultaneous absence of fricative and voiced energies

These four conditions represent the four main categories of consonants:

1 - fricative and sibilant : f, s, sh, k, t, ch

2 - voiced or liquid consonants :w, b, g, m, l, y

3 - fricative and voiced consonants : v, z, zh, j, dj, d

4 - aspirated non-voiced consonants : h, k, p

The consonants are further characterized by the presence or the absence of an energy point which is detected by checking the slope of the automatic gain control (AGC) signal, and to do that the output from the AGC device 35 is passed via the line 37 to the slope detector 145 whose output is applied, via the AND circuit 120r, to the line 148 and stored in an appropriate clamping circuit forming part of a consonant storage matrix CMS. The device CMS combines the formant energies originating from the formant-referencing system SL with the four conditions which represent the various categories of consonants, in order to give a total of 15 vectors which represent the various consonant sounds of the vocal spectrum. The energies of the formants are transmitted to the consonant matrix CMS via five lines, SDa to SDe, under the control of a formant excitation device SD into which the formants are introduced via

lines M1a to M13a. The point signal carried by the line 148 is also stored in an appropriate clamping circuit, in order to give a supplementary information bit allowing identification of the consonant. This embodiment of the present invention thus furnishes 56 vectors representing all the vocal characteristics which correspond to the various spoken elements to be identified.

Before passing on to the description of the general operation of the invention, it is appropriate to examine in detail the various elements used in the course of the description. These elements comprise the preamplifier, the automatic gain control device (AGC), the frequency selectors, the fricative sound selector, the voiced sound selector, the invertor integrators of the fricative sound selector and of the voiced sound selector, rectifiers, equality detectors, AND circuits, emitter followers, pulse shaping and integration devices, differentiators, NOR circuits, OR circuits, double invertors, clamping circuits, a conversation control latch and delay circuits.

The role of the preamplifier 2 consists in amplifying the low-level signals originating from the microphone 1 and giving out a uniform output signal, in association with the automatic gain control device which will be described later. Referring to Figure 3, the preamplifier essentially comprises five PNP-type transistors 5, 15, 20, 25 and 29 in the network presented. The first two transistors 5 and 15 serve essentially to

amplify the incident wave forms transmitted by the microphone 1. The sensitivity control device 3 serves to control the gain of the first transistor 5, the amplified output of the second transistor 15 is coupled to the third transistor 20 which, in association with the fourth transistor 25 constitutes a voltage amplifier exhibiting compression properties. The output of the transistor 25 is applied via the capacitor 26 to the transistor 29 which serves as an excitation element so as to furnish a low-impedance path for the frequency selectors F0 to F15 via the line 30. The output of the transistor 25 is also applied to the automatic gain control device 35 via the line 51.

The automatic gain control device 35 represented in Figure 5 has the role of producing an automatic gain control voltage which is applied to the preamplifier 2 as well as to the terminals of the indicator 36, which furnishes a visual indication of the moment when the voltage exceeds a predetermined threshold limit; this control voltage is sent to a transistor 50 which causes its effective impedance to vary, and it is transmitted, via the line 51, to the preamplifier, more specifically to the base of the transistor 29 via the line 28, and to the collector 24 of the transistor 25 via the coupling capacitor 26.

The normal operation of the automatic gain control circuit is fixed at plus or minus 0.4 volts, which constitutes the margin over which the sensitivity

control device 3 of the preamplifier 2 is adjusted.

The maximum overload which can be imposed on the automatic gain control device is ± 0.5 volt, and the threshold value is fixed at ± 0.3 volts. When a positive excursion exceeds 0.3 volts, the transistor 41 is turned on and turns on the transistor 47 which sends an output signal to the integrator transistor 52. Conversely, when a negative excursion exceeds -0.3 volts, the transistor 44 is turned on and applies a corresponding input signal to the integration transistor 52. The output of the transistor 52 thus causes the impedance of the variable-impedance transistor 50 to vary, and the output of the latter is then applied via the line 51 to the input of the transistor 29 and to the collector of the transistor 25 of the preamplifier 2. The output of the transistor 52 is also applied to the output line 37, which is connected to the slope detector 145.

The 14 frequency selectors 80 have the role of furnishing a very steep passband characteristic for a predetermined range of frequencies indicated in the table below.

Selector	Mean Frequency	Upper and Lower Limits
F1	3400	3120 - 3750
F2	2840	2590 - 3120
F3	2340	2140 - 2590
F4	1940	1765 - 2140
F5	1590	1458 - 1765
F6	1325	1192 - 1458
F7	1060	970 - 1192
F8	880	800 - 970
F9	720	655 - 800
F10	590	535 - 655
F11	480	444 - 535
F12	408	375 - 444
F13	340	312 - 375
F14	284	260 - 312

Referring to Figure 6, the frequency selectors 80 comprise the transistors 83 and 86 which serve as differential amplifiers, a matched-T filtering network and an output amplifying transistor 94. In operation, the sound input originating from the preamplifier 2 is applied to the transistor 83 via an attenuator 82. The output of the latter is amplified by the transistor 94 whose output is applied to the transistor 86 via the matched-T filter 88. Thus, for all frequencies other than the chosen frequency range, the input signals applied to the transistors 83 and 86 are substantially equal, with

the result that the gain is relatively low. For the selected frequency, the matched-T filter 88 lets through very small signals with the result that the output of the amplifier is a maximum. The output signal appears on the line 95, and it is applied to the formant-referencing system via the capacitor 96 and the line 97.

Referring to Figure 10, the fricative sound detector 60 serves to extract the high-frequency noises from the sound signal which is applied to it and which appears on the line 30. The sibilant selector essentially comprises an attenuator 61, an excitation transistor 62 and a differential amplifier constituted by the transistors 65 and 66 and by a delay network 67 comprising an inductor 67a and a capacitor 67b. The output of the differential amplifier is constituted by high-frequency noise signals above 4 kc/sec.

The output of the fricative sound selector is applied via a capacitor 69 to an invertor integrator 70 represented in Figure 11. This invertor integrator comprises a biasing network which allows a threshold limit to be established, in such a way that only the noise signals which exceed this limit are admitted and applied to the transistor 72. The output signal from the latter is applied to an integrator circuit 73 constituted by a diode 74 and a capacitor 75. The partially integrated signal appearing on the integration circuit 73 is then applied to an AND circuit 120o which will be described in more detail later.

The voiced sound selector 59 is a low-pass, wide-band filter which has the role of producing a cut-off below 100 cycles in order to eliminate the 60 cycle hum. The voice selector covers the range of vocal frequencies lying between 100 and 250 cycles, both for men and for women. It is extremely sensitive to speech elements such as voice stops, that is to say the voice effects obtained when the lips are closed. Referring to Figure 12, the voiced sound selector 59 is essentially constituted by a low-pass filter 53 connected to a transistor 55 which essentially has the role of an emitter follower. The output of the latter is applied to a transistor mounted in a common-base configuration 56, which plays the role of voltage amplifier in order to give a peak-limited sinusoidal output signal.

This output signal is applied to an invertor integrator 70a, represented in Figure 13, via a capacitor 57. The invertor integrator is essentially an integration network comprising a transistor 58 which furnishes an output level including only a very small proportion of noise.

The formant-referencing system is constituted by the following three basic elements; the rectifier 100, the equality detector 110 and the negative NAND circuits 120. The rectifier 100 has the role of converting the output signal from the frequency selector into a DC voltage level proportional to the peak-to-peak alternating output from the frequency selector.

Referring to Figure 7, the rectifier 100 essentially comprises a limiting resistor 102, a diode 103 and an NPN transistor 104 mounted as an emitter follower and comprising, at its output, a limiting resistor 106 and a filtering capacitor 107 connected to earth. The diode 103, in association with the transistor 104, serves as a voltage doubler for charging the filtering capacitor 107 to the total peak-to-peak value of the alternating input signal.

Referring to Figure 8, the equilibrium detector 110 comprises transistors 112 and 115 which are mounted as shown, the device serving as an equilibrium amplifier, and the transistor 117 being connected in common to the emitters of the transistors 112 and 115. By virtue of this mounting, the transistor 117 serves as a control element for limiting the current flow in the transistors 112 and 115.

The essential function of the equality detector is to compare the DC outputs originating from two adjacent rectifiers. For example, the output of the rectifier R2 appearing on the line 108 is applied to the transistor 112 of the equality detector No. 2, while the output of the second rectifier R3 appearing on the line 108a is applied to the transistor 115. In order better to understand the role of the equilibrium detector, the condition in which the DC levels applied are of equal amplitude will firstly be considered. In these conditions, and taking into consideration that the role of the

transistor 117 is to limit the total current flowing in the transistors 112 and 115 to 4 milliamperes, it follows that, owing to the equality in the DC levels, equal currents flow in the two transistors 112 and 115, which limits the current flowing in each of these transistors to 2 milliamperes. The 2 milliampere current passes through the associated resistors 113 and 114, of 2 kilohms, in which a fall of 4 volts is produced, which places the potential of the output at + 2 volts above earth, a potential at which the device is considered to be in an inactive condition.

The device is active when one or the other of the two inputs appearing on the lines 108 and 108a is greater than the other. For example, the case where the input of the transistor 112 is higher than that of the transistor 115 will be considered. In this case, the transistor 112 attracts practically the whole of the current which appears at the output of the transistor 117, i.e. approximately 4 milliamperes. In these conditions, the voltage fall in the resistor 113 of 2 kilohms at the output of the transistor 112 is substantially equal to 8 volts, which gives an active signal at -2 volts below earth.

Moreover, when the input of the transistor 115 is higher than the input of the transistor 112, the current flowing in the transistor 115 gives rise to a fall of 8 volts in the output resistor 114, which gives an active signal of -2 volts below earth.

The active output of the equilibrium detector indicates the existence of an inequality between the two rectifier output signals which are applied to it. For example, the equilibrium detector No.2 sends out an output signal which indicates that the output of rectifier No. 2 is higher than that of rectifier No. 3 (R2 > R3), or that the output of rectifier No. 3 is higher than that of rectifier No. 2 (R3 > R2).

The negative AND circuits 120 serve to determine the conjunction of two inequalities representing a local maximum. The outputs of two adjacent equality detectors, for example, the equality detectors Nos. 2 and 3, are applied to the negative circuit No. 3 which establishes the presence of a local maximum on the output line indicating that the output of rectifier No. 3 is higher than those of rectifiers No. 2 and No. 4.

The outputs of the equality detectors (that is to say two outputs of each of the equality detectors 1 to 14) are applied to the negative AND circuits 120.

As Figure 2a shows, the outputs from the equilibrium detectors 110 are applied to each of the negative AND circuits 120 for example, the outputs of the equilibrium detector No. 2 are applied to the negative AND circuits No.2 and No. 3. A negative AND circuit has the role of detecting the coincidence of negative active signals sent out by the equality detectors.

The negative AND circuit 120, which is represented in detail in Figure 9, comprises an input network

constituted by three input diodes 121, 122 and 326, of a resistor 123 and of a transistor 124 to which the input network is connected in the manner shown.

In operation, the case where the two inputs of the negative AND circuit are active will be considered (that is to say that the output signals from the equality detectors are constituted by negative signals below earth) and where a signal is applied to the diode 326. In these conditions, the three diodes 121, 122 and 326 are reverse biased, which gives rise, in the transistor 124, to the passage of a current from the emitter 124a through the base and the resistor 123, to a source of -12 volts. This results in the passage of a current in the transistor from the emitter to the source of -12 volts via the collector 124b and the resistor 125. Owing to the passage of this current, an output signal indicating the presence of the local maximum appears as a result on line 126.

When one or the other of the two inputs of the diodes 121 and 122 is positive at the moment when a signal appears in the diode 326, the potential at the base of the transistor 124 becomes higher than earth with the result that this transistor ceases to conduct and brings about a voltage fall to -12 volts at the output of the latter, which indicates a cut-off state. The output signals from the various negative AND circuits 1 to 14 representing local maxima are applied to the pulse shaping and integration device 130 which, as was seen above, have the function of eliminating interference

(that is to say the presence of undesirable transient pulses) in the signals representing the local maxima.

The pulse shaping and integration device (IPF 130) has the role of eliminating the transient pulses present in the incident signals applied to the system and of sending out an integrated and shaped output signal. The device IPS 130 represented in Figure 15a comprises the transistors 134 and 136, as well as an integration network 131 at the input of a transistor 134 and a feedback loop 137 starting from the output of the transistor 136, to the input of the transistor 134. The feedback network comprises a resistor divider circuit exhibiting hysteresis characteristics.

The hysteresis effect represented in Figure 15b may be described in the following way. A linearly increasing DC signal, when it is applied to the input network of the shaping and integration device, follows the hysteresis loop starting at point A of the loop and rises progressively up to point B while the voltage passes from -12 volts to a value approximately equal to -4 volts. For a voltage slightly exceeding -4 volts, the output of the collector of the transistor 136 rises abruptly from point B to point C, and any slight variation in the voltage at point C does not modify the amplitude of the output voltage at the level of the collector 136. In order to make the output signal cease, it is necessary to lower the input voltage to a vàlue close to -8 volts, a value for which the output voltage

abruptly falls back from point D to point E of the hysteresis loop.

In the case of alternating signals, integration takes place by virtue of the circuit constituted by the input resistor and by the capacitor mounted between the base and the collector of the transistor 134. By virtue of this circuit the alternating signals are integrated to an RMS DC input, and will have substantially the hysteresis effect which has just been explained.

The pulse shaping aspect of this circuit is due to the positive feedback loop 137 which links the collector of the transistor 136 to the base of the transistor 134. When the input potential rises to -4 volts, the transistor 134 becomes conducting, so that the voltage of the collector falls back to a value below earth. This results in the transistor 136 conducting, which brings about a rise in the signal appearing at the collector of the transistor 136, a signal which is sent back via the feedback loop 137 so as to reinforce the conduction of the transistor 134. This results in an abrupt positive excursion of the leading edge of the output wave form on the line M. When the input falls back to an effective value of -8 volts, the transistor 134 passes to the cut-off state, which brings about the raising of the voltage of the collector of the transistor 136 and this voltage is reapplied via the loop 137 to the transistor 134, so as to reinforce its cut-off state. The abrupt excursion which results ensures abrupt cut-off of

the trailing edge of the output wave form. In this way, the output IPS is a clean wave form, substantially a square wave with very steep leading and trailing edges.

The differentiators DF and D_2F are similar and differ only in the time constant which determines the length of the pulse sent out. The differentiators DF and D_2F are referenced respectively DF1 to DF14 and D_2F1 to D_2F14. The unit DF 330 represented in Figure 16a is constituted by an input differentiation circuit 332 comprising a biased isolating diode 332a for preventing the unit DF being excited by noise spikes. Two transistors 335 and 338 form a monostable circuit for production of pulses whose duration is a function of the RC product of the synchronization circuit 340 associated with the base of the transistor 338. The timing capacitor 340a is isolated from the output line by a diode 341, in order not to overload the output. The output signal may thus fall back abruptly at the end of pulse transmission and consequently constitute a good negative transient pulse for turning on the following pulse shaping device D_2F. This circuit functions in the same way as the one which has just been described except that its output pulse is shorter.

In operation, the transistor 338 is normally conducting by reason of the base current flowing between earth and a potential of -6 volts through the diode constituted by the base-emitter junction of the transistor 338 and a synchronization resistor 340c of

10 kilohms. The collector of the transistor 338 is held close to earth potential while the current flows in the collector load.

This results in the transistor 335 being cut off and held in a non-conducting state by means of the associated resistor voltage divider connected to a potential of + 6 volts, which takes the base of the transistor 335 to about 0.9 volt above earth. The other terminal of the input isolating diode 332a is at an intermediate potential between the + 6 volts potential and earth, that is to say that it is approximately equal to 3 volts above earth. Consequently, the isolating diode 332a is reverse biased by a potential at least equal to 2 volts. A negative input transition less than 2 volts remains in effect over the conduction state of the diode, and an input signal at least equal to 3 volts is necessary to bring about conduction in the transistor. In practice, an input potential from 9 to 12 volts will be applied, which ensures establishment of the excitation current of the transistor 335. When a negative-going transient pulse of this type appears at the input of the differentiator, the transistor 335 is conducting, and a positive-going transition from the potential of -12 volts to earth appears at its collector. Its collector is coupled by the diode 341 to the negative terminal of a synchronization capacitor 340a of 3.3 microfarades and by means of the capacitor to the base of the transistor 338. The steep edge applied to the base of the transistor 338

interrupts the collector current which flows there, and the potential of the collector falls back abruptly, which reinforces and holds the conduction of the transistor 335 as long as the transistor 338 remains in the cut-off state. The duration of the output pulse is thus a function of the value of the synchronization capacitor 340a and of the resistor 340c of 10 kilohms. In about 35 milliseconds, the voltage applied to the base of the transistor 338 falls back to a value close to earth and conduction is reestablished in the transistor 338. The raising of the potential of the collector gives rise to cutting off of the transistor 335, with the result that the potential of its collector falls back abruptly which puts an end to the output pulse. The output diode 341 decouples the synchronization circuit at this moment, and the synchronization capacitor continues to charge via the 10 kilohms resistor, up to 12 volts. The negative transient pulse appearing at the output of the unit DF 330 gives rise to the sending by the unit D_2F 345 of a pulse of 5 milliseconds owing to the presence in the latter unit, of the smaller synchronization capacitor. Consequently, the 35 millisecond pulse which appears at the output of the unit DF is followed by a pulse of 5 milliseconds which appears at the output of the unit D_2F each time an input pulse terminates. The differentiators DF1 to DF14 serve to send out a pulse of 35 milliseconds when the end of the local maximum is detected for a particular frequency band. The termination of this

35 millisecond pulse is detected by the differentiators D_2F1 to D_2F14, and each of the latter consequently sends out a 5 millisecond pulse.

As was seen above, the transition storage clamping circuits are excited by simultaneous application of a pulse representing an adjacent local maximum. Passing to the operating state by a clamping circuit of the transition memory prevents excitation of the corresponding constant-value clamping circuit. This inhibition is carried out for a period of 60 milliseconds after excitation of the transition clamping circuit by a 60-millisecond NOR circuit represented on line 18. In this circuit, the transistor 361 is normally conducting owing to the base current which flows in the base-emitter diode of the transistor. The base current flows between earth and a potential of -12 volts, passing through the emitter-base diode and a voltage divider which comprises the resistors 362 and 363. The collector current then flows through a resistor 364 of 1 kilohm to arrive at the source of -12 volts. Consequently the collector is held at a potential close to earth, which gives rise to activation of the line 351 which constitutes the input of a constant value clamping circuit which will be described later. A NOR circuit input capacitor 360d is charged to about 10 volts and its positive terminal is at about -2 volts, while its negative terminal is at about -12 volts. When the voltage of one or the other of the inputs of the diode, 360a or 360b, rises following the

excitation of a transition clamping circuit, the low-level side of the capacitor 360d is brought back to the 0 volt region. This rise by 12 volts is imparted to the junction 360e of the divider whose potential passes from -2 volts to about 10 volts. This results in the cut-off of the transistor and the voltage of the output line 315 falls back to -12 volts. The capacitor 360d then discharges and the voltage of the base of the transistor falls back to about earth level, which restarts conduction in the transistor. This operation takes about 60 milliseconds and allows sufficient time to prevent excitation of a constant state clamping circuit from a pulse D_2F.

The Figures 19 and 20 respectively represent the configurations of circuits capable of carrying out the OR and AND functions. The OR circuit is constituted by a certain number of input diodes 370a to 370d, connected to a common resistor 371, which is in turn connected to a potential of -12 volts. An input pulse on any of the diodes gives rise to the application of an output signal to the line 372.

The AND circuit 375 represented in Figure 20 comprises input diodes 375a, 375b and 375c, connected to a common resistor 376, which is itself connected to a source of + 6 volts. Simultaneous application of pulses on all the input diodes gives rise to sending of an output pulse on the output line 377.

The emitter follower EF represented in Figure 22

serves essentially as an excitation emitter follower mounted in push-pull of the type described in the French patent already mentioned. The emitter follower comprises two transistors 387 and 389; the base of the transistor 387 is connected to the output of the previously-described OR circuit, while the emitter of this transistor is directly connected to the base and to the collector of the transistor 389 as well as to the output of the line 389a. By virtue of this mounting, the transistor 389 plays the role of variable-impedance changer in such as way as to adjust the load to permit the transistor 387 to function effectively as an emitter follower. The latter also furnishes a positive control current when the transistor 389 sends out a negative control current, so as to deal with relatively high DC loads or to rapidly discharge the line capacitances.

The NOR circuit 410, represented in Figure 23, comprises a conventional OR circuit 400 with three inputs and one output line 401 connected to the base of a transistor 402 which operates as an emitter follower so as to furnish characteristics suitable for impedance matching at the input of two transistors 404 and 406 which play the role of a power invertor mounted in push-pull.

In operation, when all the inputs of the OR circuit 400 are negative, the transistor 402 is close to the cut-off state, while the transistor 404 is conducting, while the base current flows in the load

resistor 403 of the transistor 402. When the transistor 404 is conducting, the transistor 406 is held close to the cut-off state, while the transistor 404 applies a positive current to the chain. When the potential of any of the inputs of the OR circuit rises, the transistor 402 becomes conducting and causes interruption of the base current applied to the transistor 404, which causes the latter to pass to the cut-off state, and allows the base current to flow in the transistor 406. Consequently, the output falls back to a negative non-operating level, and the transistor 406 delivers a negative current to the load according to need. This NOR circuit 410 not only delivers a DC output signal, but it possesses a control characteristic which makes it possible to excite many other logic circuits represented in the consonant matrix system. The role of this NOR circuit 410 differs from that which was described in relation to the formant transient pulses in that the first circuit sends out only a temporary output, while this circuit sends out an output signal as long as the input signals last.

The slope detector 145 analyzes the automatic gain control wave form in order to determine the presence of abrupt negative transitions on the line 37, transitions which indicate sudden bursts in vocal intensity. The slope detector represented in Figure 5 comprises an input network 146 and the transistors 154, 160 and 165. The transistor 154, in association with the input network 146, lets through, as a function of the negative slope of

the output wave form carried by the line 37, the output of the automatic gain control device. If the slope of the wave form is steep enough, current flows in sufficient quantity to bring about conduction of the transistor 160, and this results in this transistor 160 sending out a positive-going pulse which is sent via the capacitor 155 to the base of the transistor 154 which causes a pulse to be formed. This positive pulse is directly applied to the base of the transistor 165 via a series-mounted limiting resistor 164. The output levels of the transistor 165 are normally positive and close to +6 volts. The presence of an abrupt burst in vocal intensity is manifested by a negative-going peak of the pulse of -6 volts. This peak is applied, via the AND circuit 120n which controls it, from the line 148 to the input of a voice burst indication clamping circuit represented in Figure 24.

The double invertor 390 has the purpose of furnishing complementary output signals in response to the application of an input signal via a logic device; for example, the OR circuit represented in Figure 19. The input signal is a signal of the order of 0 volts for indicating a level "1" input while a level of -12 volts serves to indicate a "0" input signal.

The double invertor represented in Figure 21 comprises an input divider network 391, two transistors 392, 394 and a diode and resistor network 393. In operation, when the "0" signal of -12 volts is applied to the input network 391, the transistor 392 is in the cut-off

state while the transistor 394 is conducting. The potential at the collector of this transistor 394 is -10 volts, and it is applied to the output line 395. At the same moment, the collector of the transistor 392 is at the 0 volt potential which is applied to the output line 396. When a 0 volt operating signal is applied to the input network 391, the transistor 392 passes to the operating state, while the transistor 394 passes to the cut-off state. Consequently, the potential at the collector of the transistor 392 is equal to -10 volts, and it is applied to the output line 396 while, at the same moment, the potential of the collector of the transistor 394 is 0 volts, and it is applied to the output line 395. In this way, the invertor 12 plays the role of connection device between the logic circuits, due to the fact that it furnishes complementary outputs as well as low-impedance circuits for the current between these logic circuits.

The functions of formant storing and indication are carried out by clamping circuits, and in Figure 17 will be found the diagram of a clamping circuit given by way of example 350. Each clamping circuit comprises an input voltage coincidence network 351, two transistors 353 and 356 and an indicator 358. Before turning it on, a zero-reset pulse is applied to it so as to bring it back to the quiescent state.

Following the zero-reset pulse, the two transistors 353 and 356 are in the cut-off state. The base of

the transistor 353 is held at a potential less than -6 volts by the output, the collector of the transistor 356. The latter is held in the locked state by a line 354 connected to the collector of the transistor 353 whose potential is close to + 6 volts. If the two inputs 351a and 351b are at potentials close to -12 volts, the base of the transistor 353 is also at a potential close to -12 volts. When one of the input potentials is at -12 volts and the other at earth level, the 10 kilohms resistor 352a mounted in the output line 352 which is connected to a potential of -12 volts limits the current to a value of 0.4 milliamperes in the equivalent input resistance of 5 kilohms, which results in a net voltage fall of 2 volts with respect to the equivalent input voltage of -6 volts. This value does not take account of the voltage fall brought about in the diode 351d which is added to the cut-off voltage. It is thus possible to hold the clamping circuit in the cut-off state while only one of its inputs is excited.

When the potential of the two inputs rises above earth (0 volts) the current flows in the base of the transistor 353 and causes it to pass to the operating state. The voltage of the collector falls back and causes the transistor 356 to pass to the operating state. The potential at the collector of the transistor 356 rises to close to earth potential, which causes the lamp to light. The 10 kilohms resistor 352a mounted between the output and the base of the transistor 353 supplies sufficient

base current to hold this transistor in the operating state even if the voltage of the two inputs falls back to -12 volts. The input insulating diode 351d is, in this case, reverse biased, with the result that the base current does not escape from the base circuit of the transistor 353. Hence, the clamping circuit remains in the operating state until it is brought back to the quiescent state.

When the zero-reset or clear key R is actuated, a zero-reset pulse, from 0 volts to -12 volts, is applied to the emitter of the transistor 353 and causes it to pass to the cut-off state. The lamp goes out and the transistor 356 passes to the cut-off state. This results in the potential of the base of the transistor 356 rising to +6 volts so that the transistor remains in the quiescent state when the common zero-reset line returns to 0 volts. It is possible to incorporate a delay device into the zero-reset line, in the manner shown, in order to carry out the zero reset when power is applied. Clamping circuits will be found in the FTS and ISD units which serve to store decreasing (S) and increasing (R) transitions as well as constant formants (S). The clamping circuits also serve, in the consonant matrix CMS, to store vectorial characteristics representing the consonant sounds of the vocal spectrum.

The conversation control latch 303, Figure 14, is excited in response to the actuation of a key PT during the utterance of words into the microphone 1 with a view

to their identification. The output of this latch excites the gate line 325 connected to all the AND circuits 320 of the formant-referencing system, which allows insertion of all the formats identified, including the signals which are representative of voiced and fricative sounds, into the formant transition detection device and into the consonant matrix. No speech element is stored with a view to its identification if the conversation control latch is not in the operating state.

Referring to Figure 14, the conversation control latch 303 essentially comprises four transistors 308, 312, 314 and 320 and a synchronization capacitor 306 connected to the input circuit which arrives at the base of the transistor 308. All these elements form part of the network circuit which constitutes the conversation control latch. The operating and nonoperating commands for the latch are connected to the PT key which comprises the normally-closed contacts a and b. In the operating control circuit a delay device 300 is interposed, which provides protection against contact bounce in the switch during actuation of the latter.

When the conversation key is in the normal position, the transistor 308 is held in the cut-off state and the 5 microfarad delay capacitor 306 is fully charged. The transistor 314 is also in the cut-off state owing to the negative bias applied by means of the closed contacts b at the key PT, to the line 302 and to the diode 315 which holds the base of the transistor 314

close to -12 volts. The transistors 312 and 320 are conducting owing to their connection with the collectors of the transistors 308 and 314 respectively. The output of the conversation control latch is therefore held close to +6 volts which is the non-operating level or "0" level of the input of the NAND circuits which it controls.

When the PT key is pressed, the synchronization capacitor 306 starts to discharge to earth via the 10 kilohms resistor 304. The clamping provided by the diode at the base of the transistor 314 also ceases. However, the transistor 314 remains in the cut-off state as long as the transistor 312 is conducting. After an interval of about 50 milliseconds, the transistor 308 is conducting and cuts off the transistor 312 whose potential at the collector rises, with the result that the transistor 314 sends current through the lamp 316, and the transistor 320 also passes to the cut-off state. The output appearing on the line 325 then falls back to the negative operating level close to -6 volts. All the negative AND circuits connected to the line 325 are held excited by virtue of this negative level. At the end of the sending of a word, and when the PT key is released, the base of the transistor 314 is clamped at -12 volts with the result that the potential of the collector rises and turns on the transistor 320 which raises the output of the line 325 close to +6 volts. This results in the de-energizing of all the negative AND circuits, which allows the synchronization capacitor to charge to -12 volts via

the 100 ohm resistor.

The delay circuit represented at the bottom of Figure 2b provides a delay of 1 second for clearing the zero-reset circuit of the clamping circuits, when the current is applied to it. All the voltages are normal, and the clamping circuits are in non-operating state when the zero-reset circuit is closed. This gives the assurance that all the storage clamping circuits are in a non-operating state when the current is applied.

The system goes into operation when the operator presses on the PT key represented on line 2c. This key causes the conversation control latch (TCT303) to pass to the operating state, which furnishes a gate signal to the line 325 connected to all the AND circuits 120a to 120n represented on line 2a and also to the AND circuits 120o, 120p and 120r represented in Figure 2c. When the sound energy produced by the voice of the operator or by any other source passes into the microphone 1, it is sent into the preamplifier 2 which furnishes a compressed speech envelope, an envelope which, as a consequence of the dynamic effect of the automatic gain control unit (AGC 35) is a constant level.

This compressed speech envelope is applied to the frequency selectors FS of Figure 2a, 14 in number, which bear the reference 80, and which are tuned in such a way as to detect a specific frequency band lying between 3750 and 260 cycles per second. The compressed speech envelope is moreover applied to the fricative sound selector 60

and to the voiced sound selector 59, also represented on Figure 2c, which supply integrated and inverted output signals when fricative and voiced frequencies are found in the speech spectrum. The output signals furnished by the frequency selector in response to the detection of the presence of a particular frequency band are applied from these various selectors to appropriate output lines, for example line 95 which arrives at the formant-referencing system FL represented on line 2a.

As was seen previously, the formant-referencing system uses three basic units: the rectifiers 100, the equilibrium detectors 110 and the AND circuit 120. If the succession of rectifiers and equilibrium detectors is examined, it can be seen that the presence of formants, that is to say of energy peaks in a particular frequency band appears on the outputs of equilibrium detectors 110 which are 13 in number in the embodiment represented. If, for the moment, the equilibrium detector BD 2 is considered, the upper line, reference R_2 R_3, develops a negative signal when the quantity R_2 (output of rectifier 2) is greater than R_3 (output of the rectifier 3). In contrast, when the quantity R_3 is greater than R_2, the lower line, which carries the reference R_3 R_2, receives a negative signal from the equilibrium detector BD2. However, when the inputs of the equilibrium detector BD2 have the same amplitude, no negative signal appears on one or the other of the outputs in question. Each time a local maximum is present, a pair of output lines

receives, in coincidence, negative signals which give rise to the transmission of this output signal via the associated AND circuit of the group which bears the references 120a to 120n, towards the associated pulse shaping and integration device 120, these shaping devices being 14 in number and bearing the references IPS1 to IPS14. This pulse shaping and integration device has the role of eliminating any undesirable transient pulses which may appear in the applied wave form which represents the presence of a formant in the speech spectrum.

At the output of the various pulse shaping and integration devices the energy constituted by the formants of the spectrum comprise both vowel characteristics and consonant characteristics. An explanation will now be presented of the way in which the vowel characteristics are detected, which are indicative of decreasing transitions, of increasing transitions, or of invariable formants. The detection of the increasing and decreasing transitions is provided by the differentiators DF1 to DF14, in association with the clamping circuits for decreasing values 350, represented in Figures 2b and 2d. The invariable formants, that is to say the constant formants, are detected and stored by the differentiators D_2F1 to D_2F14 in association with the NOR circuits and the constant state clamping circuits 350 which are also represented in Figures 2d and 2b.

The description of the detection of decreasing

and increasing transitions will be understood by considering what happens for frequencies immediately above or immediately below a given frequency band. An increasing transition is defined as the transition detected in a frequency band immediately above a given frequency band in which the end of a formant has been detected. In contrast, a decreasing transition is the transition detected in a frequency band immediately below that of a a given frequency band in which the end of a formant has been detected.

In order to explain the precise action of the conditions above, by way of reference in Figure 2 the pulse shaping and integration device 2 will be considered, and in particular its output line M2 on which the termination of a local maximum is detected (that is to say a formant) associated with the given frequency (that is to say the chosen frequency) detected by the frequency selector S2. The line M2 represented on the drawing is connected to the upper input of the clamping circuit 2R and also via the paralleling line M2′ to the lower input of the clamping circuit 1F as well as to the input of DF2. Supposing, moreover, that an increasing transient pulse appears on the line M1 at the moment when the line M2 reaches the local maximum, it transpires that the increasing transition indicated on the line M1 is transmitted to the upper input of the clamping circuit 1R, which applies a 0 voltage level to the latter. Consequently, when the local maximum is reached on the

line M2, a signal of -12 volts is applied to the input of the differentiator DF2, which gives rise to the application of an output voltage of 0 volts to the output line DF2a. This output is held during the 35 millisecond interval, as will be appreciated from the timing diagram represented in Figure 16b. The 0 volt output is also applied to the lower input of the clamping circuit 1R. The presence of this 0 volt potential on the two upper and lower inputs of the clamping circuit 1R causes the latter to pass to the "1" state in the manner described above. Passing to the "1" state by the clamping circuit 1R gives rise to the sending by the latter of a signal on the output line M2R in order to indicate one of the vowel characteristics of an increasing transition.

In order to explain the effect of a decreasing transition with respect to the end of a local maximum on the line M2, the appearance of a transient pulse on the line M3 will be considered (the line M1 remaining inactive), at the moment when the local maximum is reached on line M2. It will be appreciated from these considerations that the 0 volt potential is applied to the lower input of the clamping circuit 2F. At approximately the same moment the output of the line DF2a also applies a 0 volt potential to the upper input of the clamping circuit 2F. Consequently the clamping circuit 2F passes into an operating state and sends out an output signal onto the line M2F which indicates the presence of a vowel characteristic presenting a decreasing

transition.

In order to take account of the effect of a constant or invariable condition, for which an invariable formant is present, it will be considered that there are no temporary pulses on the line M1 nor on the line M3 at the moment when a local maximum is reached on the line M2. In these conditions, the lines M3 and M1 apply a signal of -12 volts to the lower input of the clamping circuit 2F as well as to the upper input of the clamping circuit 1R. The other inputs of these two clamping circuits are held at the 0 potential for 35 milliseconds owing to the time constant of the differentiator DF2. Given that only one of the inputs of this clamping circuit 1R and 2F is at the 0 volt potential, these clamping circuits cannot pass to the "1" state. The expiry of the 35 millisecond pulse originating from the differentiator DF2 causes the differentiator D2 F2 to send out a 5 millisecond pulse which is applied to the upper input of the clamping circuit 2F which serves to store the invariable formants. The lower input of this clamping circuit is connected to the output of the NOR circuit 2 whose a and b inputs respectively are connected to the outputs of the clamping circuits 1R and 2F which, as was seen above, are both in the "0" state at that moment. Given that none of the inputs of the NOR circuit 2 is excited, the 60 millisecond negative inhibition pulse does not appear, which gives rise to the application of a 0 voltage to the lower input of the

clamping circuit 2F. At the same moment, a 0 voltage is applied to the other input of this clamping circuit, which gives rise to the clamping circuit 2F passing to the "1" state. The output of this clamping circuit is applied to the line M2F which indicates a fixed characteristic, that is to say invariable, of one of the vowels of the sound spectrum. In this way, the present embodiment furnishes 14 invariable characteristics M1S to M14S, 13 increasing transient characteristics M2R to M14R, i.e. a total of 40 vectors on the lines bearing the appropriate references in Figures 2b and 2d which constitute the vowel characteristics of speech.

A description will now be given of the development of the consonant characteristics. The consonant characteristics derive from formants sent out by the formant-referencing system SR represented in Figure 2a and which furnishes formant outputs on the lines M1 to M14. These formants are transmitted via lines M1a to M13a which are connected to the formant excitation device MD represented in Figure 2e. The formant control or excitation device comprises the OR circuits 370, the double invertors (DI) 390, the AND circuit 375n, the emitter followers 385 and the NOR devices 410. These devices are connected in the manner represented to each of the output lines bearing the references FDa, FDb, FDc, FDd and FDe. These outputs are combined with the four consonant catagories which bear a code $\bar{F}.\bar{V}$, F.V, $\bar{F}.V$, and $F.\bar{V}$, which are transmitted on lines bearing the

appropriate references connected to the input of the consonant storage matrix CMS which can be seen in Figure 2f. These four coded outputs are developed by the fricative and voiced sound excitation device FVT represented in Figure 2c. These coded outputs derive from fricative and voiced energies appearing respectively on the lines FO and VO represented in Figure 2c. The latter lines are connected specifically to a pair of double invertors 390 which each furnish complementary outputs, in the manner described above, to four lines DIa, DIb, DIc and DId connected in the manner indicated to four AND circuits whose outputs bear the references $\bar{F}.\bar{V}$, F.V, $\bar{F}.V$ and $F.\bar{V}$. The AND circuits of the fricative and voiced sound excitation device FVD are made conducting by a common control device, connected to a consonant switch CF. These four catagories, coded as has been seen above, represent the four essential consonant catagories, namely:

1/ the fricatives and the sibilants - f, s, sh, k, t, ch;
2/ the voiced or liquid consonants - w, b, g, m, l, y:
3/ the voiced fricatives - v, z, zh, j, d;
4/ the non-voiced aspirates - h, soft k, p.

These four fricative and voiced energy conditions are combined with the formants produced on the lines M1a to M13a by means of the storage device of the consonant matrix CMS in order to give 15 consonant characteristics on output lines bearing the appropriate references, namely f, w, v, s, m, z, sh, l, zh, k, g, j, h, k' and

h'. The present embodiment thus furnishes 15 consonant characteristics, 40 vowel characteristics, including an abrupt-peak characteristic, i.e. a total of 56 characteristics which make it possible to completely encompass the various voice emissions of the speech spectrum.

By way of example of the method of representation of a vowel by means of vectors the English vowel sound "i" will be considered. It relates to a composite vowel pronounced "ahee" which is represented in the present system by a vector code of 9 bits represented by the following lines: M2F, M3S, M5S, M6R, M7R, M9F, M10F, M11F, M13S.. This is the unique code of the vowel "i" pronounced as above and analysis reveals that the effect of the formant is as follows.

1° The lower frequency of the formant is fixed and is indicated by the vector M13S.

2° The immediately higher formant starts at M9 and falls back by two frequency bands to M11 where it terminates, which is indicated by the vectors M9F, M10F, M11S.

3° The immediately higher formant starts at M7 and rises by two frequency bands up to M5 where it terminates, which is indicated by the vectors M7R, M6R, M5F.

4° The highest formant starts from M2 and falls back to M3 where it remains fixed, which is indicated by the vectors M2F, M3S.

It can thus be seen that with 9 information bits

it is possible to render a relatively complicated vowel; but what is more important is that a single code is obtained for a given vowel, whatever the circumstances.

Although what has been described in the foregoing and represented in the drawings are the essential characteristics of the invention applied to a preferred embodiment of the latter, it is evident that the person skilled in the art can apply thereto any modification of form or detail which he judges useful without in any way departing from the scope of the said invention.

ABSTRACT

The subject of the present invention is a speech analysis and identification system, characterized by the following points considered in isolation or in combination:

1 - The system comprises: several wave form analyzers each producing an output amplification which is a function of the energy present in the analyzed wave form; a peak energy detection device sensitive to the energies present in the adjacent wave forms analyzed in such a way as to produce local maxima signals, at a rate of one for each local maximum detected; a transition device for detecting the peak energy transitions arising between adjacent wave forms; and a device for translating the transitions detected in the form of coded bits, each representing a particular and significant characteristic of a sound in the analyzed sound spectrum.

2 - The system comprises several frequency analyzers, each of them being sensitive to a particular frequency band present in the sound spectrum analyzed and producing an output amplification which is a function of the energy present in the frequencies analyzed.

3 - Fricative and voiced sounds analyzer are provided, tuned respectively to the frequencies of fricative and voiced sounds present in the spectrum, comprising means for producing appropriate fricative and voiced output signals.

4 - Formant energy detection devices operate in response to the energies present in the adjacent frequency bands analyzed in such a way as to produce formant signals, at a rate of one for each formant detected.

5 - A formant transition device detects peak energy transitions arising between adjacent formant signals.

6 - An invariant energy detection device is linked to the abovementioned formant transition device in such a way as to detect the presence of invariants, this detection device comprising means for translating the invariants into the form of bit-coded signals.

7 - A device is provided for translating the formant transitions detected in the form of coded bits, each representing a particular and significant characteristic of a vowel sound in the spectrum.

8 - A fricative and voiced sound matrix operates

in response to the fricative and voiced output signals in such a way as to supply coded fricative and voiced signals representing different classes of fricative and voiced energy present and absent in the sound spectrum.

9 - A consonant matrix operates in response to the formant signals and to the coded fricative and voiced signals in such a way as to furnish coded signals characteristic of the consonants in the sound spectrum.

10 - The formant transition detection device comprises: a network comprising several first differentiation members, each of them being linked to a different formant transmission line and operating in response to an end-of-formant in such a way as to furnish a differentiated output signal on an output line, each of these output lines being associated with a particular frequency band of the spectrum; several increasing transient storage members and several decreasing transient storage members, these members being associated in pairs each comprising one member of the first type and one member of the second type, each of these transient storage members having one output and one pair of inputs sensitive to the coincidence of input signals, each pair of transient storage members being linked to a differentiated output line, different in such a way as to constitute a parallel arrangement in which any of the differentiated output lines represents a band of frequencies between an adjacent, higher frequency band and an adjacent, lower frequency band of the spectrum and either an increasing

transient storage member, or a decreasing transient storage member of each pair of storage members, being sensitive to a coincidence of input signals constituted by an associated differentiated output signal and by a transient signal, either increasing or decreasing, associated with an adjacent frequency band, according to whether an increasing or decreasing transient respectively is produced, in such a way as to store an instance of the appropriate transient.

11 - The invariant detection device comprises: several second differentiation members having inputs linked respectively to the outputs of the first differentiation members, each of them being sensitive to a first differentiated output signal in such a way as to produce a second differentiated output signal; several comparison members, each of them having a pair of inputs and one output, each pair of inputs being linked to a different pair of transient storage outputs associated respectively with an increasing transient storage member and with a decreasing transient storage member, the said comparison members furnishing a constant output signal in response to the simultaneous absence of an increasing transient and of a decreasing transient in the associated storage member; and several invariant condition storage members, each of them being sensitive to a coincidence of a second differentiated output signal and of a constant output signal in such a way as to store and instance an invariant sound characteristic.

pl.1

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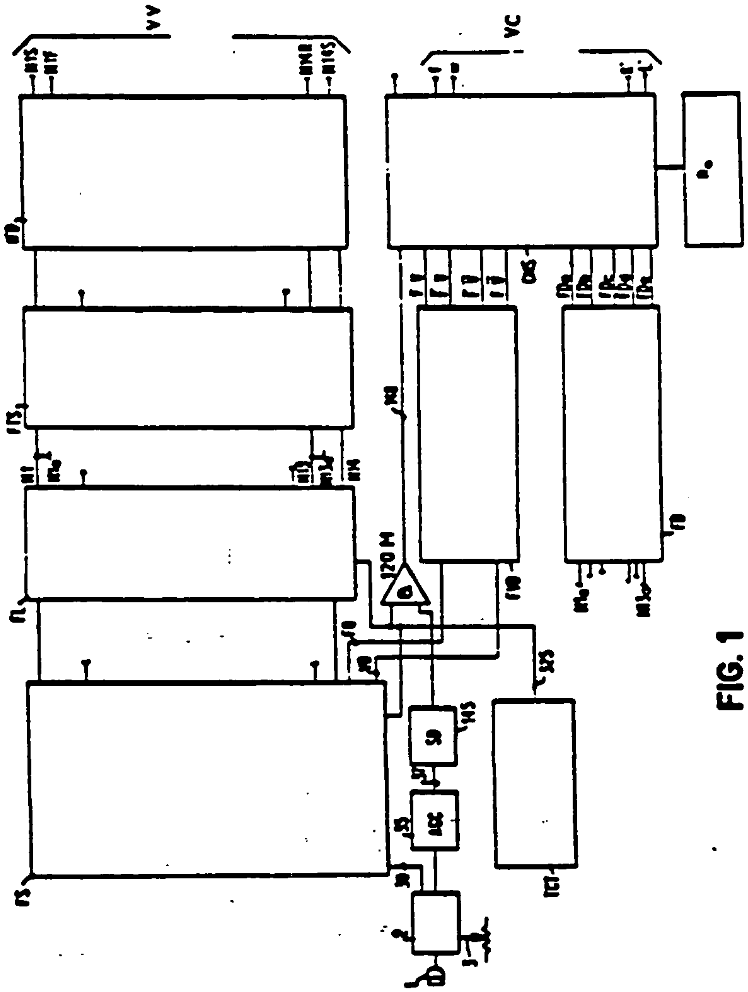

FIG. 1

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FIG. 2a

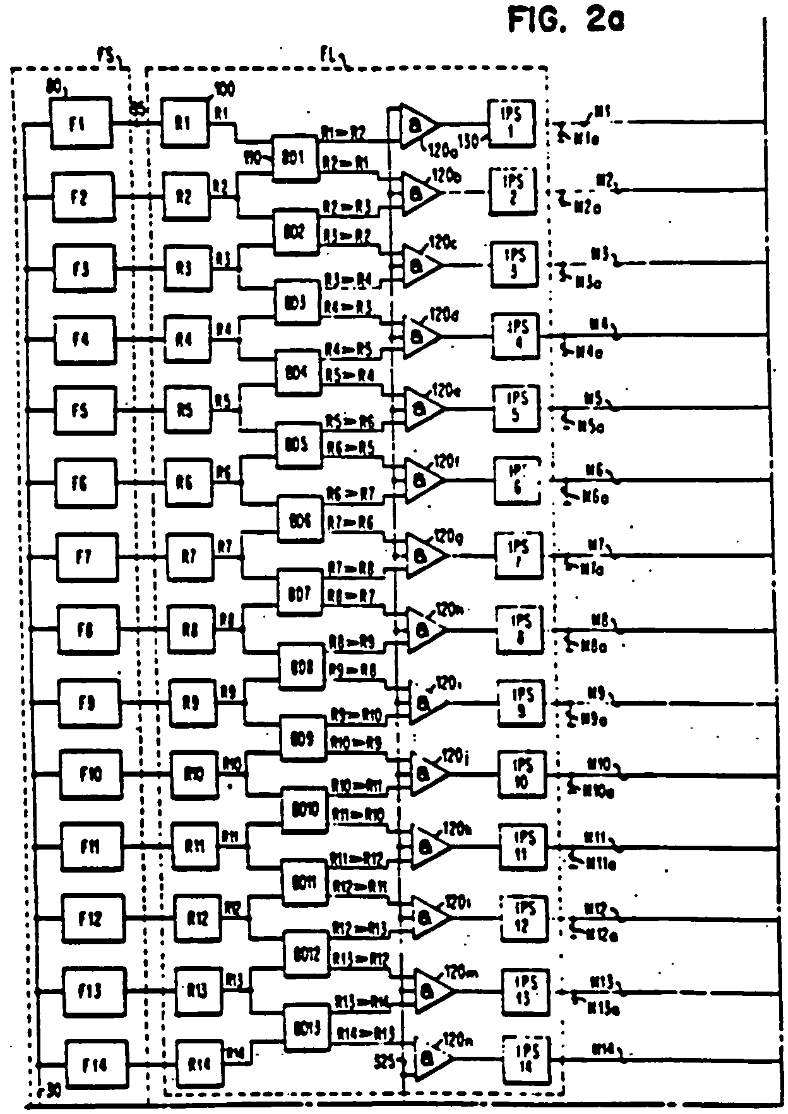

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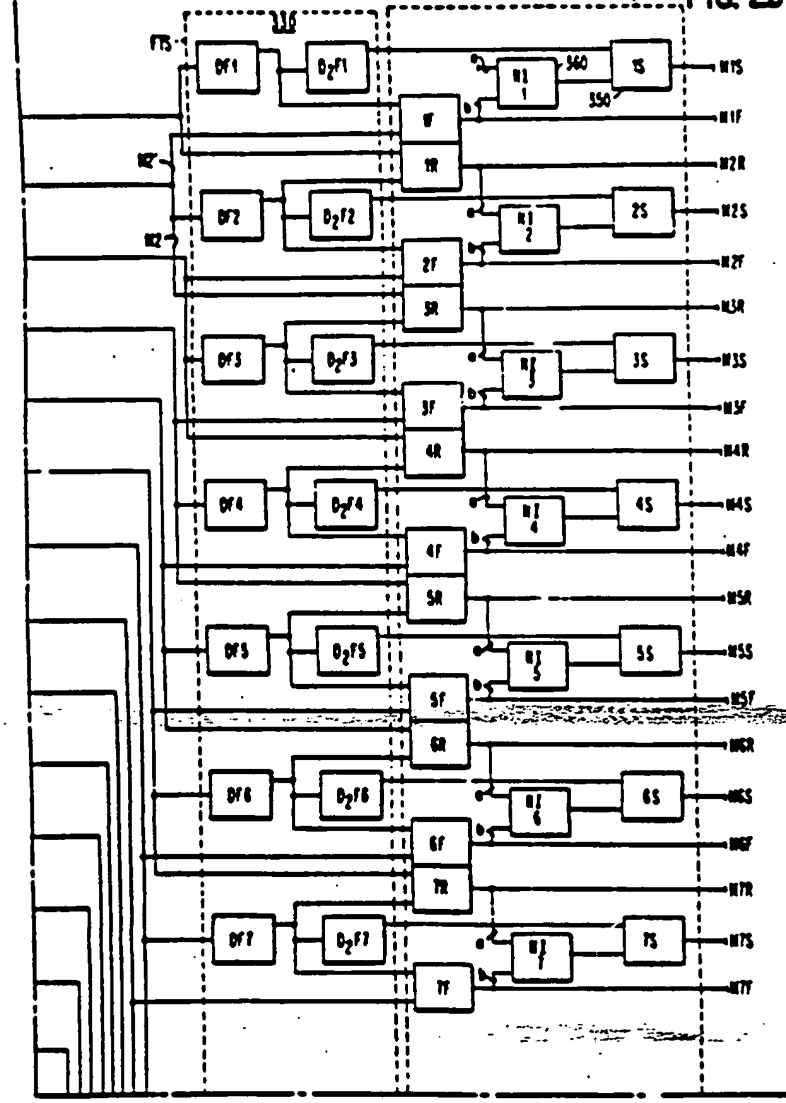
FIG. 2b



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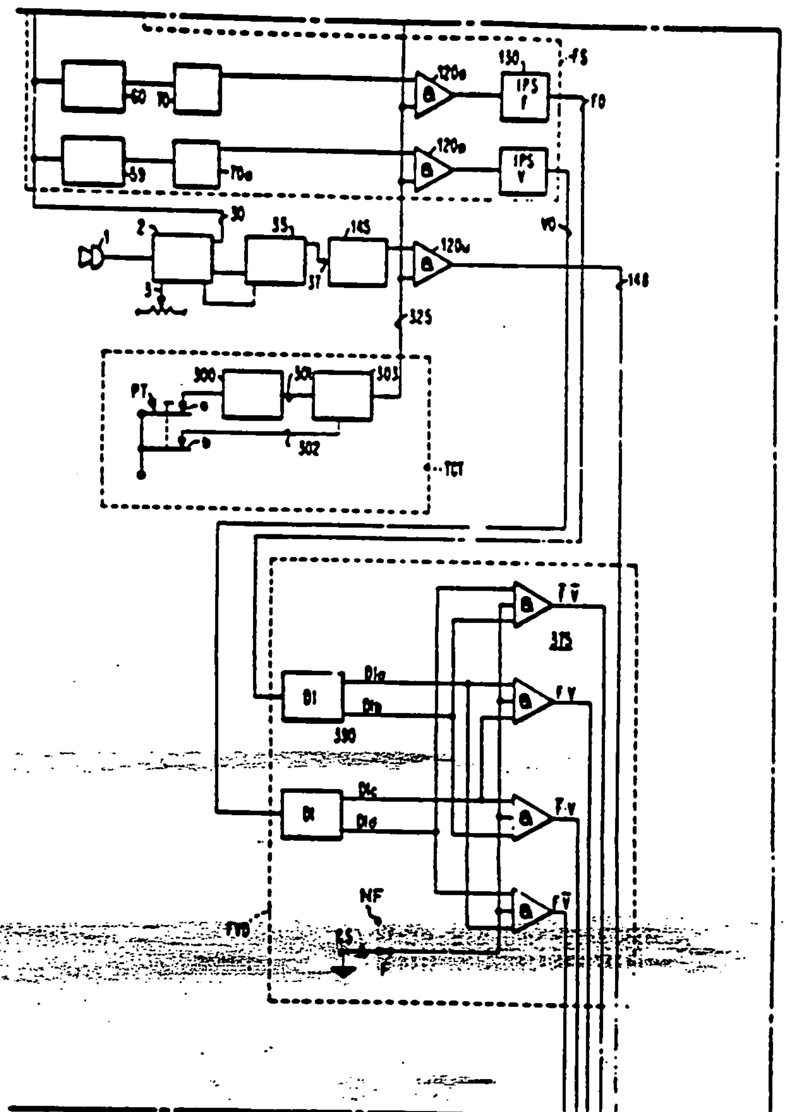

FIG. 2c

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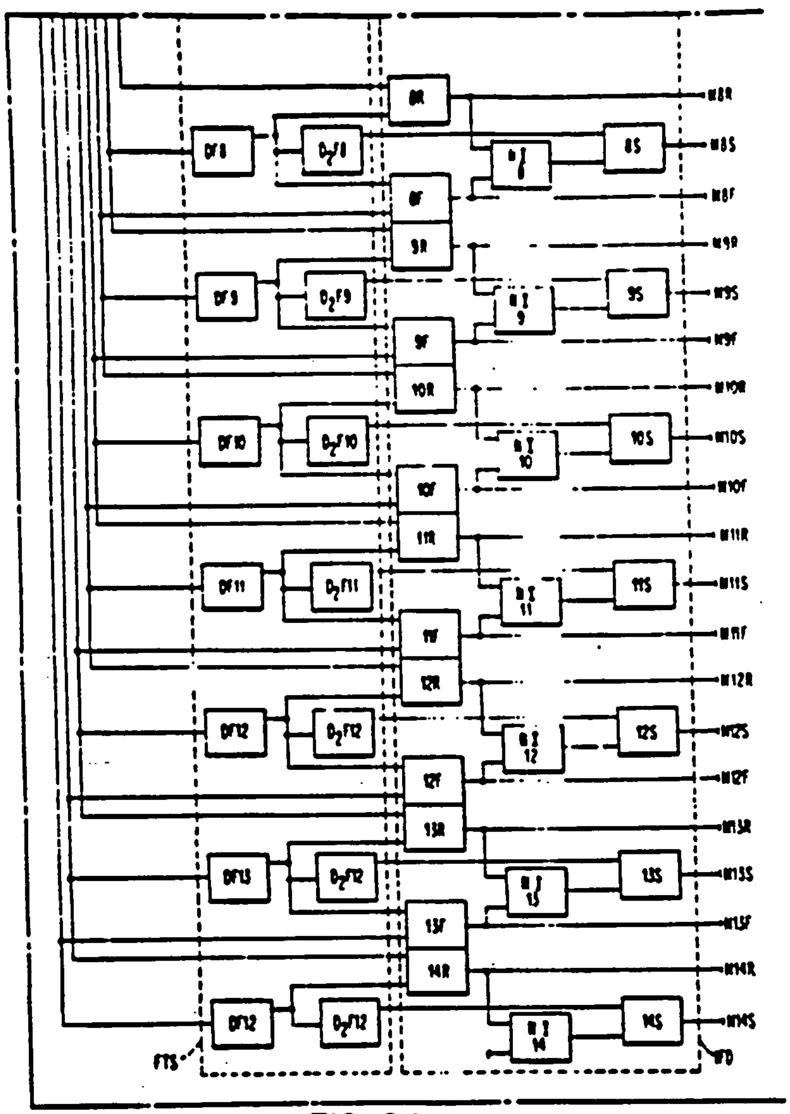

FIG. 2d

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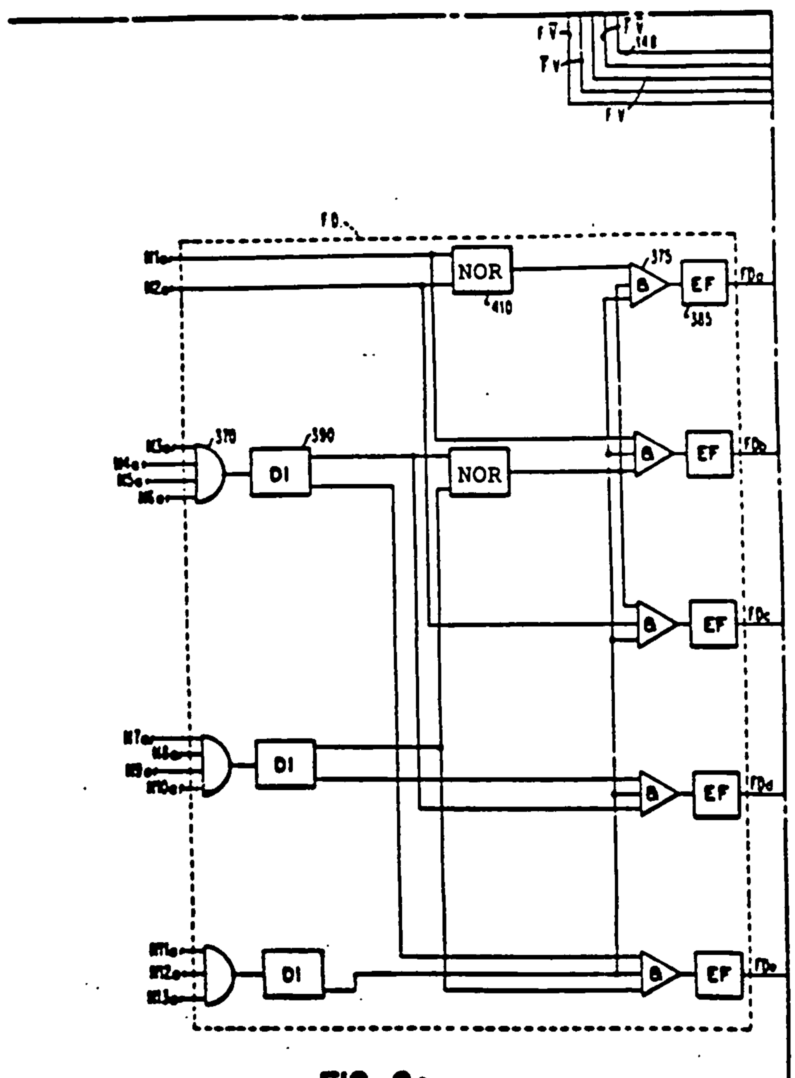
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FV
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FDa
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FIG. 2e

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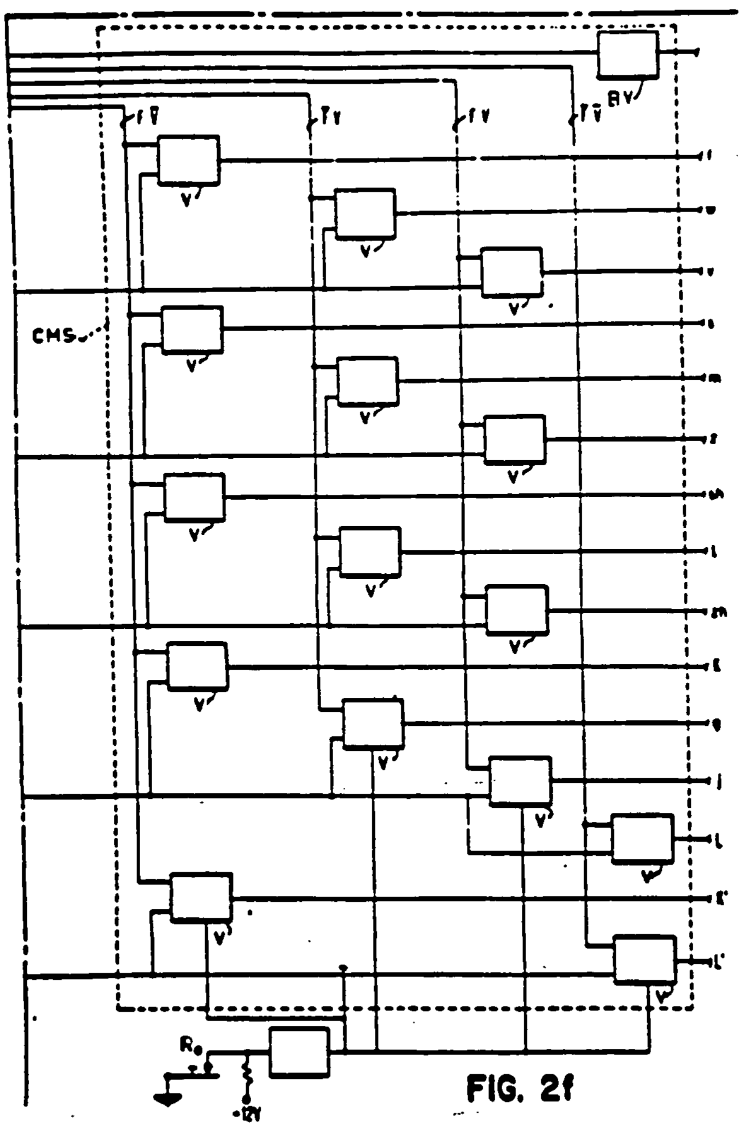

FIG. 2f

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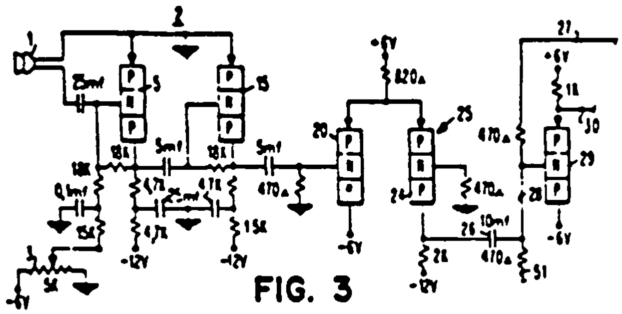

FIG. 3

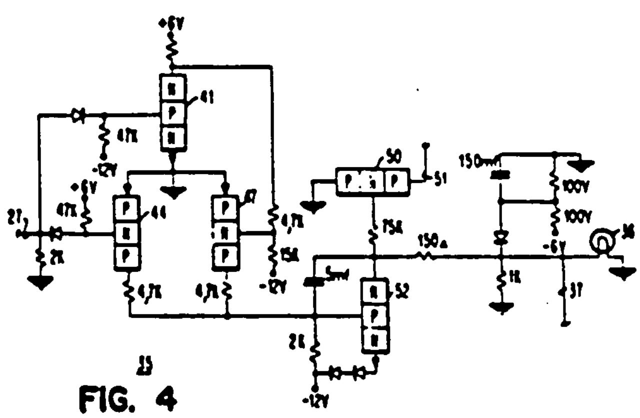

FIG. 4

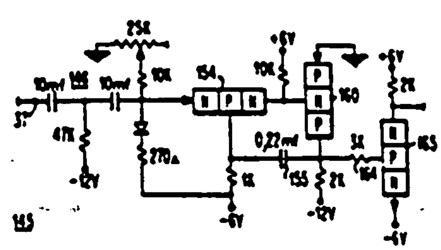

FIG. 5

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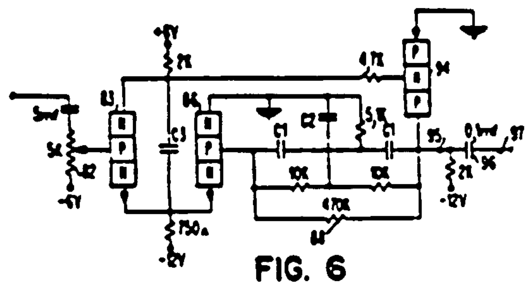

FIG. 6

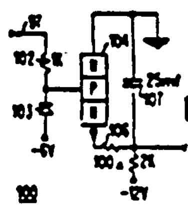

FIG. 7

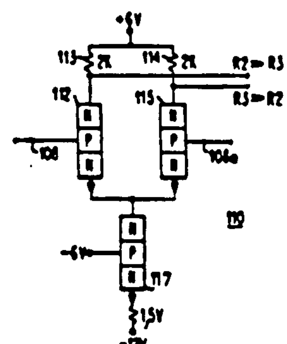

FIG. 8

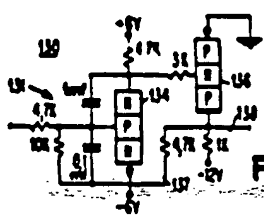

FIG. 15a

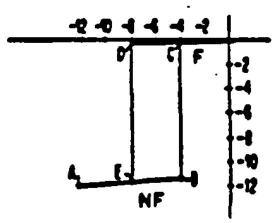

FIG. 15b

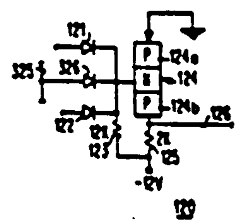

FIG. 9

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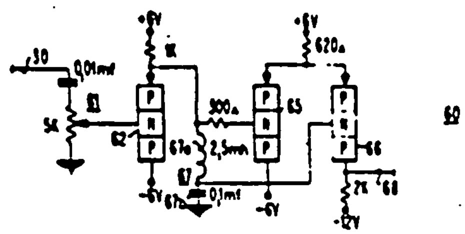

FIG. 10

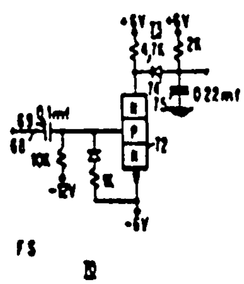

FIG. 11

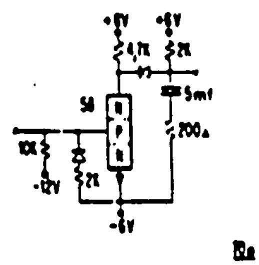

FIG. 13

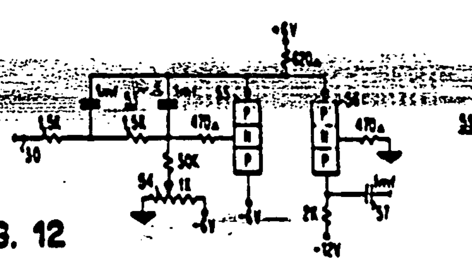

FIG. 12

(illegible stamp)

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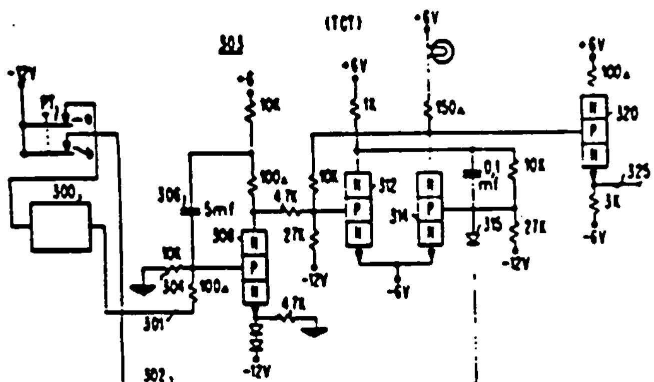

FIG. 14

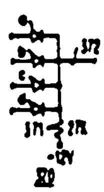

FIG. 19

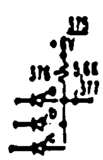

FIG. 20

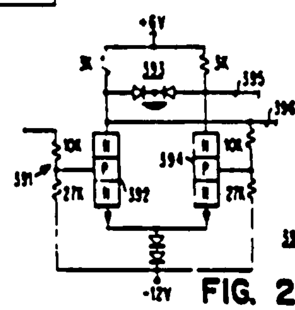

FIG. 21

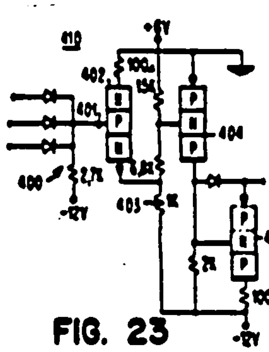

FIG. 23

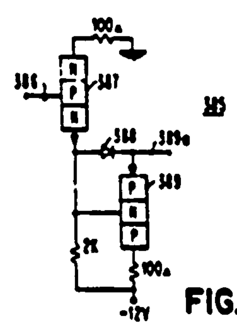

FIG. 22

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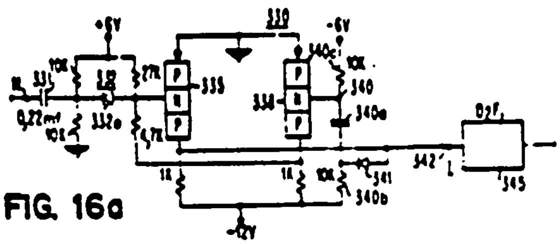

FIG. 16a

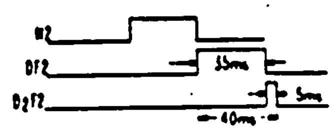

FIG. 16b

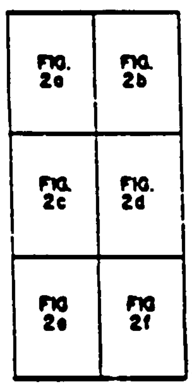

FIG. 2

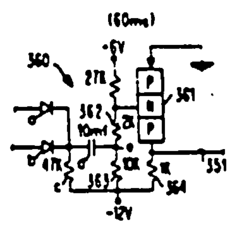

FIG. 18

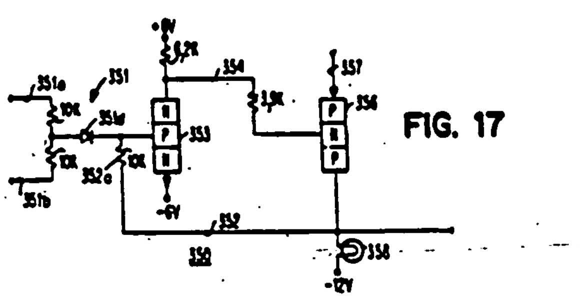

FIG. 17

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(signature)

Translator's Report/Comments

Your ref: 47273/T Your order of (date): Mar 4, 1992

In translating the above text we have noted the following apparent errors/unclear passages which we have corrected or amended

Page/para/line*	Comment
6/7	'établit' should probably be 'établie'.
6/14	'prectre' → 'spectre'
9/2/4	'de gain' inserted between 'commande' and 'automatique', so that 'AGC' is the correct English abbreviation.
17/3/12	A word has been missed at the end of the line, presumably 'qui'.
18/last	'à' inserted before 'un', to read '<u>at</u> a potential'.
19/6	'est' appears superfluous.

* This identification refers to the source text. Please note that the first paragraph is taken to be, where relevant, the end portion of a paragraph starting on the preceding page. Where the paragraph is stated, the line number relates to the particular paragraph. Where no paragraph is stated, the line number refers to the page margin line number.

Translator's Report/Comments

Your ref: 47273/T Your order of (date): Nov 4 1992

In translating the above text we have noted the following apparent errors/unclear passages which we have corrected or amended

Page/para/line*	Comment
20/2/13	'contant' has been interpreted to mean 'courant'.
26/2/8	There is a superfluous letter 'x' at the end of the word 'consommes'.
26/3/2	One of the transistor numbers, 312, was omitted from the list.
28/2/8	'formatives' is interpreted as 'fricatives'.
28/3/3	'avancement' looks odd in the context, and might have been meant to read 'agencement' (arrangement)

* This identification refers to the source text. Please note that the first paragraph is taken to be, where relevant, the end portion of a paragraph starting on the preceding page. Where the paragraph is stated, the line number relates to the particular paragraph. Where no paragraph is stated, the line number refers to the page margin line number.

Translator's Report/Comments

Your ref: 47273/T Your order of (date): Nov 4, 1992

In translating the above text we have noted the following apparent errors/unclear passages which we have corrected or amended

Page/para/line*	Comment
29/2/5	'indicatrices' → 'indicatives'.
30/2/19	'colt' → 'volt'.
31/3/13	'une' should apparently read 'd'une'.
32/1/4	'la' should apparently read 'là'.
32/2/12	'en' should probably be 'un' – English to read '-- which bear a code ---'.
36/10/17	'au' would make more sense as 'du'.
" " /20	'constiutée' → 'constituée'.

* This identification refers to the source text. Please note that the first paragraph is taken to be, where relevant, the end portion of a paragraph starting on the preceding page. Where the paragraph is stated, the line number relates to the particular paragraph. Where no paragraph is stated, the line number refers to the page margin line number.

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